DEPARTMENT OF AGRICULTURE,
CEYLON.

BULLETIN No. 62.

THE WEST AFRICAN OIL PALM AND ITS PRODUCTS.

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DEPARTMENT OF AGRICULTURE, CEYLON.

BULLETIN No. 62.

THE WEST AFRICAN OIL PALM AND ITS PRODUCTS.

UP to the present time all of the supplies of palm oil and palm kernel oil for the world's markets have been obtained from uncultivated oil palms on the west coast of Africa. Much of the palm oil from that source is of poor quality, and owing to the system of land tenure, it does not seem easy to improve the methods or to increase the areas of production. Attention has, therefore, been turned to the possibility of replacing the present industry by systematic plantations.

The Dutch appear to be the only nation which has definitely embarked upon this new project, and in 1922 the plantations in Sumatra totalled 28,000 acres. It is planned to extend the area in that Colony to a maximum of about 100,000 acres in the next ten years. The French, English, and Belgians control the oil-producing areas of Africa, and have given less attention to the founding of plantations elsewhere, but reports from their colonies show that the improvement of existing areas would probably involve as many difficulties and as much expense as would the foundation of a systematic plantation industry.

The change from the state of affairs in which a product is collected from uncultivated areas to that in which it is produced from plantations is usually slow. In the case of the oil palm there is little information of a precise and reliable nature regarding profits and yields, and practically none concerning the behaviour of the plant under systematic cultivation. The facts that do appear to be known are that the market for the oil is likely to be firm for some time, the demands for fats and oils are increasing daily, and that the quality and yield of plantation oil are likely to be better and steadier than they are under existing conditions.

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Trade Figures.

The following figures give some idea of the magnitude of the oil palm trade:—

British Colonies, Exports from.

	Palm Kernels. Tons.	Palm Kernels. Value. £	Palm Oil. Tons.	Palm Oil. Value. £
1911	232,978	3,412,399	61,040	—
1912	250,448	3,802,467	58,155	—
1913	229,713	4,198,913	56,074	—
1915	197,723	3,559,014	75,435	2,640,225

The remainder of the world's trade is shown in the following table:—

	Kernels. Tons.	Palm Oil. Tons.
French Colonies (1915)	27,381	71,520
German Colonies (1913)	37,055	15,038
Belgian Colonies (1915)	11,023	3,407

In round figures there are, therefore, 300,000 tons of kernels and 100,000 tons of palm oil marketed annually. These figures may be compared with those for the two great industries of coconuts and rubber: in 1919 the exports from the tropics of copra was 236,016 tons, of coconut oil 161,825 tons, and of rubber (1916) 129,299 tons.

The average prices in England for the years given above work out as follows:—

	Kernels. Per Ton. £ s. d.	Palm Oil. Per Ton. £
1911	14 13 0	—
1912	15 4 0	—
1913	18 5 0	—
1915	18 0 0	35

In Appendix I. at the end of this bulletin are given quotations of prices in Liverpool during 1921 and 1922. It will be noted that kernel oil, which is prepared in European factories, brings a price gradually approaching that of coconut oil, whereas palm oil, prepared by crude methods, is of less value.

Palm Oil and Kernel Oil.

The fruit of the oil palm is covered with a pulp of varying thickness, containing a large proportion of fatty oil, which is known in trade as "palm oil" or "pulp oil." Within this

The palms here were planted 29 by 29 feet apart on the square system, or 50 to the acre, and the yields obtained were as follows :—

Age of Trees.		Yield per Tree.
Fourth year from seed	..	41·9 pounds fruit
Fifth year from seed	..	112·5 pounds fruit

From his observations and experience, Rutgers estimates the following yields from good, average Sumatra plantations in the future :—

		Estimated yield of Fruit Annually.		
Age.		Per Tree. lb.		Per Acre. lb.
5th–10th year	..	53	..	2,650
11th–30th year	..	165	..	8,250
31st–50th year	..	66	..	3,300

It must be confessed that the available information is scanty and uncertain for the purpose of estimating the prospects of a new industry. It is all that is available, however, and it is therefore necessary to exercise all the more care in framing estimates. By using the figures for average composition of the fruit arrived at in the previous section of this bulletin, the following yields of oil and kernels are indicated.

Yields per Acre of 50 Trees, in lb.

	Fruits.		Nuts.		Palm Oil.		Kernel Oil.
African averages ..	3,000	..	1,650	..	600	..	210
Sumatra, 5–10 years ..	2,650	..	1,457	..	530	..	291
Sumatra, 11–30 years ..	8 250	..	4,537	..	1,650	..	907
Sumatra, 31–50 years ..	3,300	..	1 815	..	660	..	363

The "nuts" of the second column refer to the fruits less pulp, and are the parts of the fruits shipped for production of kernel oil and quoted in market reports as "palm kernels." Their weight is taken as being 55 per cent. that of the fresh fruit.

With kernels at £18 per ton and palm oil at £35 the value per acre of the produce shown in the table above would be as follows :—

Gross Value per Acre of Produce per Year.

	Palm Oil.				Kernels.				Total.		
	£	s.	d.		£	s.	d.		£	s.	d.
African averages ...	9	7	6	..	13	5	2	..	22	12	8
Sumatra, 5–10 years .	8	5	8	..	11	14	2	..	19	19	10
Sumatra, 11–30 years	25	15	8	..	36	9	2	..	62	4	10
Sumatra, 31–50 years	10	6	3	...	14	10	3	..	24	16	6

The gross returns per acre would, therefore, appear to be fairly high, but it must be kept in mind that the figures given by Rutgers for yields in the eleventh to thirtieth years are practically assumptions. In addition, the cost of machinery has to be considered, while the fruit needs a considerable amount of labour for its reaping and transport.

Habit of the Palm.

The botanical name of the oil palm is *Elaeis guineensis.* Male and female flowers occur on the same individual tree, but are on separate inflorescences or bunches, the male bunches being, as a rule, in the upper parts of the palm, and the female ones in the lower parts. An idea of the shape and general appearance of the bunches and fruits can be gained from the accompanying illustrations (Plate I.).

Fertilization of the female flowers is effected usually by means of insects which bear the pollen from tree to tree. In most cases the male and female flowers of an individual palm mature at different times, so that self-fertilization is not usual. There seems to be some ground for the belief that many flowers are not visited by insects, and that not more than 25 to 50 per cent. of the female flowers develop into fruit; if this be correct, it is possible that pollination by hand will be found profitable enough to become a matter of daily routine on the estate.*

Mature fruits vary in weight from 5 grams to 15 grams (30 to 90 fruits to the pound), and the whole bunch weighs from 10 to 30 lb., including the stalk, flower, stems, &c. The actual fruit on the bunch may vary from 5 pounds to 25 lb. in weight (150 to 1,500 fruits to the bunch), or about 60 per cent. of the weight of the whole bunch. The size of the fruit and the relative proportions of pulp, shell, and kernel seem to depend, in the first place, upon the type or variety, but are also influenced by conditions of soil and rainfall.

In extreme cases flowering may begin at two years of age, more often at three. The average age is, however, four years, and the palm never reaches full maturity and bearing before its seventh year. Where rainfall is evenly distributed over the year, fruit is produced every month, and reaping is therefore, as in the case of the coconut, practically continuous. Where a marked drought exists, months of greater and less productivity are apparent. The following figures give the average

* Hand-pollination has apparently become part of ordinary estate routine in Sumatra. The method employed is discribed fully in the Sumatra Bulletin reviewed in the "Tropical Agriculturist," Vol. 59. No. 6.

percentages of fruit reaped monthly in West Africa and Sumatra from January to December :—

Sumatra : 6·4 ; 6·5 ; 7·5 ; 9·0 ; 9·7 ; 10·7 ; 11·7 ; 8·6 ; 7·1 ; 8·3 ; 7·3 ; 7·2.

Congo : 6·8 ; 14·7 ; 11·0 ; 10·0 ; 14·4 ; 9·2 ; 9·6 ; 8·3 ; 11·2 ; 1·9 ; 2·4 ; 0·5.

Under ordinary conditions the palm remains low enough to enable the fruit to be reaped without ladders up to its twelfth year of age, though eventually a height of 30 to 40 feet may be reached. The height at various ages is to a certain extent dependent upon soil, light, and methods of treatment. Neglected trees in West African forests tend to become tall and slim at an early age, whereas widely spaced palms on cultivated plantations grow stoutly and are shorter. The practice of cutting off the leaves below developing bunches of fruits increases the yield of fruit considerably, but if carried to excess causes the palm to increase in height at a relatively early age.

Climate and Soil.

The oil palm ranges naturally over an area extending from Gambia to Portuguese West Africa, that is, from 12° north to 12° south, and from the sea coast up to elevations of about 4,000 feet. It is clear that in this immense area it must occur on many different soils and in many variations of climate, and that it cannot be regarded as particularly delicate or fastidious. In Ceylon it grows at Anuradhapura without irrigation and with an annual rainfall of 54 inches unevenly distributed, and in Galle or Kandy with rainfalls from 80 to 100 inches.

The same remarks, however, might apply to the coconut. It is not safe to be guided by mere observation of the localities in which a tree will grow, but only by a comparison of the yields obtained in different localities and under different conditions, and information on these points is scanty in the case of the oil palm.

Observers in the Belgian Congo state that the oil palm is found at its best in low-lying, well-watered, alluvial soils, near the banks of rivers, and that on stiff, clay soils in the higher, interior lands the yield of fruit is smaller. Sumatra authorities put 40 inches of rain, well distributed, as the minimum upon which the oil palm can be expected to thrive profitably. On the other hand, stagnant water round the roots has been found to be fatal to the productive powers of the palms. The root system of the oil palm is said to be shallower and less robust than that of the coconut, and to

need a soft or well-tilled soil and a good supply of moving water in the soil. No information is available concerning the tolerance of the palm for salt water, so that it is not known whether, like the coconut, it can be planted on the seashore.

On the whole, the information obtainable leads to the conclusion that the oil palm finds its best conditions in localities and soils very much the same as those suited to the coconut or to rubber, with the exception that it is probably less tolerant of salt than is the coconut, and more tolerant of moisture than is rubber, while rubber will probably thrive better in a clay soil than the oil palm will. Extended trials are, therefore, needed before the palm can be recommended by the Department of Agriculture as a crop suited for those districts of Ceylon in which coconuts and rubber do not thrive. Such trials have been begun at Anuradhapura.

Methods of Cultivation.

The methods adopted in the Sumatra plantations appear to be precisely similar to those used for coconuts all over the tropics. The seedlings are set out at a distance of 30 by 30 feet on the square system, but the Department of Agriculture in that Colony states that this is too wide and recommends 25 by 25 (70 palms per acre). On the quincunx system, it is probable that 25 feet apart would be the minimum distance advisable, and this would give about 82 palms to the acre.

The ordinary precautions regarding cleaning, draining, and terracing are similar to those for rubber or coconuts, and need not be detailed here. No information regarding manuring is available, excepting statements that the palm responds to care and manuring. Green dressings or other catch crops may be grown between the lines of palms up to four years of age on the average. Tillage of the soil, particularly in clay areas, is reported to be absolutely necessary, if good growth and yields are desired.

Three points which need more attention than in the case of coconuts are (1) removal of mosses, ferns, and epiphytes from the leaf bases; (2) pruning away of the leaves below maturing bunches; (3) hand pollination of the flowers. The leaf bases of the oil palm persist longer than those of the coconut, the trunk rarely being smooth and clear, and consequently mosses and ferns stifle the young flower shoots. Each flower stalk or bunch arises in the axil of a leaf, and it has been observed that the weight of the bunch is increased by as much as 50 per cent. if the supporting leaf is cut back after the flowers are fertilized and young fruits are well formed.

Plate V. - Young oil palm from which lower leaves have been removed. Bunches of fruit are shown.

Various trials have been made to obtain information regarding germination. The minimum period has been found to be three months, and the usual nine to twelve months. The seeds are extraordinarily resistant, and germination is more rapid if they are steeped for some time in hot water. Cracking or filing the nuts was found to be without effect.

Diseases.

The oil palm is no more immune from pests and diseases than are other crops, and no doubt the problem will become more serious on highly cultivated areas than under natural conditions.

The pests already known to attack the palm are (1) Rhinoceros Beetle, (2) Red Weevil, (3) Bud Rot, (4) Fungus known as Ganoderma.

Three species of the Rhinoceros Beetle (*Oryctes boas, O. monoceros, O. owariensis*) are reported to attack the bud in Portuguese Congo, the attacks being similar to those inflicted upon coconuts by an Oryctes in Ceylon. The Red Weevil (*Rhyncophora palmarum*) is considered to be almost certainly a pest of the palm in Malay. Bud Rot, a disease, probably bacterial, of the bud, is reported from Portuguese Congo.

Ganoderma lucidum is reported from Nigeria and Portuguese Congo and *Ganoderma applanatum* from St. Themé and Principe. In both cases a dry rot of the base of the stem is caused; in the final stages the whole base is decayed into a dry, mouldy powder, and bracket fructifications appear on the outside of the trunk; the earliest symptoms are the gradual withering of the outer leaves, and the subsequent passage of the symptoms to successive inner leaves until the bud is reached. The disease is stated to be invariably fatal.

The prevention of the Rhinoceros and the Red Weevil is largely a matter of sanitation, as in the case of coconut plantations. Bud Rot is not well understood, and in any event is difficult to treat, attacked trees are usually felled and burnt. *Ganoderma* is stated to enter through wounds in the trunk, and, in addition to ordinary precautions, special care should be taken to tar the cut surfaces exposed after leaves have been pruned back.

Reaping and Extraction.

In so far as the field work of manufacture is concerned, the two main problems demanding attention are the transport of fruit to the factory and the preservation of the pulp from damage or decay.

Pulp oil becomes rancid with extreme rapidity until it is separated from its pulp, and all ripe or plucked fruit has to be handled within 24 hours. Much of the West African palm oil contains from 20 to 50 per cent. of free acid arising from rancid fermentation of the pulp, and this acidity is precisely the character objectionable to the buyers, and of which plantation grown oil is expected to be free. Rancidity is due to an organized ferment (enzyme), and arises through over-ripeness, damage to surface of the fruit, and delay in removing and crushing the pulp. It is prevented by thorough sterilization of the fruit with steam, and thus steaming or boiling is the first process in the palm oil factory, being used both to prevent rancidity and to render the pulp soft and easily removable. In working on a large scale it is possible that fruit will have to be roughly graded according to quality before crushing, so that decayed, damaged fruit may be kept separate from sound ones.

The weight of fruit is on the average about 60 per cent. that of the whole bunch ; in other words, of every 100 lb. of bunches brought to the factory, 40 lb. represent wasted labour. It does not appear possible to allow the fruit to fall from the bunch, nor can the fruit be stripped from the bunches by hand easily and cheaply. Two courses are therefore possible, either the transport of the whole bunches to the factory and separation of the fruit by machine there, or the separation of the fruit by machinery or hand at several points on the plantation and transport of the fruit alone to the factory. There seems very little doubt that on a plantation the first of these would ordinarily be found more workable and cheaper in the end.

In West Africa, in the native industry, the whole work of reaping, separating, steaming, pestling, and crushing or boiling is performed slowly and laboriously by hand. Where dealers handle produce on the spot, the whole bunches apparently are brought in by the natives, and the fruit separated and treated by machinery. Presumably in the latter case payment is made by weight of bunch.

Some idea of the total transport and labour of reaping may be gained by consideration of the following figures. An average acre of 50 palms should yield eight bunches of fruit per tree annually, each bunch weighing 20 lb., and containing 12 pounds of fruit. The total weight of bunches would, therefore, be 8,000 pounds per acre. A factory turning out 1,000 tons of palm oil per annum would need an area of about 2,000 acres, and would handle about 5,000 tons of fruit.

Factory Work.

The names of several engineering firms who manufacture machinery for handling oil palm are given in Appendix II. of this bulletin, and catalogues and estimates may be obtained from them.

The processes necessary in dealing with the fruit of the oil palm may be summed up as follows :—

(*a*) Separating fruit from bunches.
(*b*) Steaming or boiling the fruit.
(*c*) Removing the pulp (depulping).
(*d*) Pressing out the pulp oil.
(*e*) Cracking the seed shells.
(*f*) Separating broken shells from kernels.
(*g*) Pressing out the kernel oil.
(*h*) Refining the oils.

In the event of the grower deciding to ship whole seed instead of preparing kernel oil, the first four and the last one of these processes are the only ones necessary.

It is not possible to give details of cost or construction of the machinery necessary for these processes, but a few indications may be found of interest.

Machines are supplied for working by hand power, or by oil engine or, other mechanical means. The hand power machines are useful for small areas, and the best types are reported to do good work, although the extraction is naturally not as effective as that of the power-driven machine.

For oil extraction there are several distinct methods. Some machines remove the pulp from the seed, and the pulp is pressed separately, others crush the pulp without removing it from the seed. In another pattern, which has been discarded almost entirely, the whole fruit is crushed, the two oils being thus obtained mixed ; it has been found preferable to prepare and ship the two oils separately, however, as they are used for somewhat different purposes.

One of the difficulties of manufacture has been the separation of broken shells from the kernels, if the shells and kernels are pressed together, the oil is not affected in quality, but the valuable oil cake is spoilt for the purpose of stock feeding. The difficulty of separation appear to have been overcome by the use of spiked travelling belts which pick up soft kernels and pass over shells, and also by immersing the shells and kernels in a salt bath of known density in which the shells sink and the kernels float. In addition to these, there are various riddles and sieves which are effective.

For a small plantation it would be possible to make use of a hand depulper and a small steam vat, and to ship the whole kernels to Europe. The cost of freight on kernels is, however, high, and it is probable that a large plantation would find it profitable to prepare the kernel oil in the factory. The cost of a fully equipped factory to handle the produce of about 1,000 acres would be considerable, and was before the war estimated at £1,000 per 5 tons daily crushing, this price being for machinery alone, excluding buildings, boilers, and engine.

Summary.

From the information available it seems likely that the production of palm oil and kernel oil will in future become as highly specialized a plantation industry as rubber or coconut oil. The estimates of yield made in this bulletin are, on the whole, conservative ones, and they indicate that the industry will be a profitable one at present prices. They do not, however, point to any special advantage of yield or profits over the coconut industry. Experiments in Sumatra show that the best results are secured where the rainfall is considerable. Cultivation expenses should be about the same for the two crops, returns per acre do not differ materially, and the outlay on buildings and machinery are higher in the case of the oil palm.

The position in general is one of some interest. There seems to be a concensus of opinion that the trade in fatty oils is likely to be a great and growing one in the future, and that the haphazard methods of production which exist in the case of West African palm oil would be with advantage replaced by a stable and cleanly plantation industry. The oil palm seems to respond to cultivation, and the yield per acre will no doubt be forced to a higher figure on efficient plantations than is at present realized.

Appendix No. I.

Prices on Quay Liverpool of Palm Oils.

(Messrs. Lewis & Peat, 6, Mincing Lane, E. C., 3.)

Prices per Ton of 2,240 lb.

	Palm Kernels.			Palm Oil. Lagos.		Palm Oil. Congo.		Kernel Oil.		Coconut Oil. Cochin.		Coconut Oil. Ceylon.	
	£	s.	d.	£	s.	£	s.	£	s.	£	s.	£	s.
Oct., 1921	18	0	0	36	0	32	0	40	0	53	0	44	0
Nov.	18	10	0	37	10	32	10	40	0	49	0	43	0
Dec.	18	10	0	38	10	33	10	38 to 44	0 0	48	0	42	0
Jan., 1922	17	2	6	36	10	31	10	37	0	44	0	40	0
Feb.	19	0	0	41	0	36	0	39	0	43	10	41	0
March	18	10	0	37	0	32	0	38	10	42	10	40	0
April	18	5	0	34	10	30	0	38	0	41	0	39	15

Appendix No. II.

Firms making Machinery for handling Products of the Oil Palm.

(Vats, Depulpers, Nut Crackers, Oil Presses, Oil Refining Apparatus, &c.)

Scotts, 72, Oxford street, London.
A. F. Craig & Co., Paisley, Scotland.
Greenwood & Batley, Albion Works, Leeds.
Rose, Downs & Thompson, Old Foundry, Hull.
W. E. Fischer, Monument Station Buildings, London.
Miller Bros., 21, Water street, Liverpool.
Robert Boby, Ltd., of Bury St.Edmunds.
Vacuum Tool Co., Ltd., of Adelphi, London, W.C.

Appendix No. III.

Composition and Feeding Value of Palm Kernel Cake.

(From Imperial Institute's Monograph on Oil Seeds and Feeding Cakes, 1917.)

	Kind of Seed Cake.		
Composition.	Palm.	Linseed.	Cotton. (undecosticated).
	Per Cent.	Per Cent.	Per Cent.
Moisture	12·0	10·0	10·5
Crude proteins	18·5	33·5	24·5
Fat	5·5	8·6	6·5
Carbohydrates	50·0	31·7	26·3
Fibre	10·0	8·7	25·0
Ash	4·0	6·5	7·2
	100·0	100·0	100·0
Starch equivalent	78·8	71·8	39·2
	£ s.	£ s.	£ s.
Cost per ton	6 0	12 0	7 0
Cost of one food unit	1 5	2 8	2 3

Appendix No. IV.

Modern Uses of Fatty Oils.

The following notes on the composition and uses of fats and oils may be of interest to the reader. One hears or reads about such products as "stearine," "margarine," "oleo margarine," glycerine, soap, "linoleum," "rubber substitute," and "hydrogenated fats" without perhaps quite understanding what they

are. Recent developments in the manufacture of these and similar products are largely the cause of the great increase in the demand for vegetable fats and oils :—

Composition of Fats.

All vegetable and animal fats are compounds of glycerine with certain acids. The commonest acids found combined with glycerine to form fats are palmitic, stearic, oleic, myristic, and lauric, the compounds of these are named palmitin, stearin, olein, myristin, and laurin. The proportions in which these occur in different natural fats vary considerably, and as the melting point of each differs from those of others, there result hard and soft fats, semi-liquid fats, and liquid fats or oils.

Soap and Glycerine.

Upon treatment of a hot oil with soda or potash, glycerine is set free, and the soda or potash combines with the various acids to form a soap. Soda makes a hard soap, potash a soft one, and in both cases palmitic acid is the chief acid present. Glycerine is used as a base for various explosives.

Glycerine can be set free from the acids of fats by substances other than soda or potash. Water possesses this power, particularly in the presence of certain enzymes which are produced by bacteria. Palm oil from over-ripe or damaged fruit turns "rancid," that is, is split up so that free acids are formed, and palm fruits are sterilized by steam before being crushed so as to prevent this rancidity. Low grade African palm oils contain up to 50 per cent. of free acid, while manufacturers fix a maximum of 8 to 10 per cent. in oil of good class.

Linoleum and Rubber Substitutes.

Those fats and oils which "dry" in the air, such as linseed oil, absorb oxygen or sulphur easily and form solid waterproof material. These products are, however, neither so strong nor so elastic as rubber, and can be used only for special purposes. Linoleum is a compound of linseed oil with oxygen, mechanically mixed with cork chips, resin, and kauri gum. Sulphured "drying oils" are used for cheap, imitation "rubber," textiles.

Stearine, Oleo-margarine, and Margarine.

Certain of the components of fats and oils separate out in solid form if the oil or fat is cooled. Coconut oil and palm oil, for example, are partly solid in cold weather. By cooling the fat to different low temperatures and filtering under pressure the whole series of components (palmitin, stearin, olein, &c.) can be separated from one another. The solid components are used to replace wax for candles, or butter, lard, or tallow for food, lubrication, &c.

Cleanly prepared margarine, flavoured with cream or butter, is a good and healthy food, and is replacing butter on an immense scale.

Hydrogenation of Fats and Oils.

The process known as "hydrogenation" of oils has done more than any other to increase the demand for liquid oils. All fats and oils will combine with hydrogen under certain conditions, and the result is to render them more solid. Fully hydrogenated palm oil, for example, melts at 150° F, ordinary palm oil at about 70° F.

The immense convenience of a process which will convert liquid oils into solid fats is obvious. Edible substitutes for butter, hard lubricating fats, materials for candle-making, can now be made from liquid oils. The process is a highly technical one, and has to be carried out in specialized factories. Hydrogenated fats if prepared in a cleanly fashion are not unwholesome.

Appendix No. V.

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Plate I.—Oil palm cultivation at Anuradhapura Experiment Station.

pulp is a hard nut, containing a kernel or "seed," in which there is a fatty oil of different composition from the pulp oil, and known as "kernel oil." Both of these oils are in demand, and are the chief products of the palm. A brief account of the uses to which fatty oils of this nature are applied is given in Appendix IV. of this bulletin. The pulp ferments rapidly after the fruit is ripe or removed from the tree, and for this reason palm oil must be prepared on the plantation. The kernel, being protected by its stout shell, will keep in good condition for long periods, and kernel oil has therefore in the past been prepared in Europe. Machines for cracking the shells and for pressing out the kernel oil have been perfected, and in the future the kernel oil will probably be prepared on the plantation, in order to save freight on the shells, which are heavy and of little use except as fuel, and on the kernel residue, which is a valuable feeding stuff for live stock.

The fibrous, watery residue left from the pulp after removal of the palm oil is of no value, and is returned to the soil as manure. Palm oil cake or palm kernel cake, the residue left of the kernels after the oil has been pressed out, is in great demand in Europe; its composition, feeding value, and market price in Europe are given in Appendix III. at the end of this bulletin.

A product which is of less value than kernel cake is known as "kernel meal." This results from a process whereby the kernel is ground fine after pressing, and the residual oil extracted with solvents, such as ether. Meal is practically devoid of oil, as compared with kernel cake containing 5 to 8 per cent., and is not often prepared, since it is found more profitable to produce the cake as a valuable by-product.

In Africa the oil palm is tapped for toddy or spirit in the same manner as are the coconut, palmyra, kitul, and date in Ceylon and India. The annual yield of sap per tree as determined by the Nigerian Department of Agriculture is as follows :—

	Gallons.
1917	18·1
1918	12·0
1919	8·5
1920	7·8

The regular diminution in yield each year is striking. Yields of different palms were found to vary considerably, ranging from ½ gallon up to 32 gallons per year.

Percentages of Oil and Cake.

The oil palm appears to vary in the size, shape, colour, and composition of its fruit to as great an extent as does the coconut. Extreme cases of types giving fruits with 20 per cent. up to 80 per cent. of pulp and correspondingly high and low percentages of shell and kernel are found, and a whole series of types occur with percentages varying between these extremes. Some of these variations are due to differences of soil, climate, and treatment, but there is little doubt that marked hereditary differences do occur, and that seed intended for planting would have to be carefully selected from known, good types.

The following table gives the results of the examination of the oil palm fruits from the Anuradhapura Experiment Station, Ceylon, by the Imperial Institute, London :—

	Present Samples.		Previous Samples examined in 1920.		"Abepa" from the Gold Coast.	
	No. 1 (Green).	No. 2 (Black).	(1)	(2)	(1)	(2)
Fruits.						
Average length, inches	1·10	1·07	1· 1	—	1·55	1·2
Average diameter, inches	0·72	0·69	0·75	—	0·95	0·8
Average weight, grams	4·7	3·7	5·1	—	12·2	7·0
Pulp, per cent.	27·7	27	23	—	31	29
Nut, per cent.	72·3	73	77	—	69	71
Pulp.						
Moisture, per cent.	4·3	3·9	4·5	—	13·6	16·3
Oil, per cent. Expressed on moist pulp	65·8	64·5	62·7	—	69·2	65
Oil, per cent. Expressed on dry pulp	68·8	67·1	65·6	—	80·0	77·6
Nuts.						
Average, length, inches	0·84	0·84	0·8	0·7	1·2	1·0
Average diameter, inches	0·65	0·63	0·7	0·5	0·85	0·7
Average weight, grams	3·4	2·7	3·5	1·6	8·3	4·4
Average thickness of shell, inches	0·09	0·08	0·11	0·08	—	0·15
Kernel, per cent.	25·1	25·6	22·5	25	25	31
Shell, per cent.	74·9	74·4	77·5	75	75	69
Kernels.						
Average length, inches	0·54	0·54	0·5	0·4	0·8	0·7
Average diameter, inches	0·45	0·41	0·4	0·3	0·55	0·4
Average weight, grams	0·8	0·7	0·8	0·4	2·1	1·6
Moisture, per cent.	6·3	6·1	5·5	5·4	23·7	20·0
Oil, per cent. Expressed on moist kernels	53·7	53·1	52·6	55·5	—	41·0
Oil, per cent. Expressed on dry kernels	57·3	56·5	57·8	58·8	—	51·0

Plate II.—Mature bunch of oil palm fruits,
Anuradhapura Experiment Station.

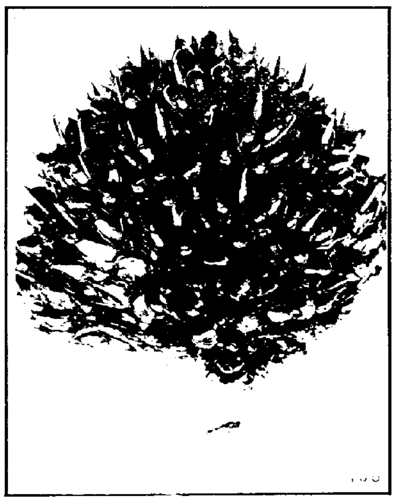

Plate III. Mature bunch of oil palm fruits. Anuradhapura Experiment Station.

The following table gives figures for the composition of the fruit obtained by various workers in the tropics :—

	Air-dried Fruits. (Ceylon Grown.)	Air-dried Fruits. (Gold Coast.)	Plantation Fruits. Sumatra.	Selected Types.	Un-cultivated Palms.
Pulp oil	17	20	33·0	25	16
Kernel oil	10	9	3·6	6	9
Shell	54	52	32·0	40	44
Pulp residue	10	10	27·0	23	16
Kernel residue	9	9	4·4	6	15
	100	100	100·0	100	100

The variations appear very marked, but when the figures are analysed the table is of considerable value and interest. The figures in columns 1 and 2 are for the type known as "Abopa," and the analyses were performed by the Imperial Institute on samples which had air-dried on the voyage. All of these figures are probably, therefore, higher than they would be for fresh fruits of similar type, and, in addition, as the pulp probably loses more moisture than does the seed, the proportion of pulp to seed is less than in moist fruits.

Column 3 is compiled from figures obtained by A. A. L. Rutgers from about 4,500 bunches of fruits grown on plantations and in gardens in Sumatra. His averages were pulp 60 per cent., shell 32 per cent., kernel 8 per cent., and an average of 55 per cent. oil in the pulp and of 55 per cent. in the kernel have been assumed. The extremely high proportion of pulp in these fruits is very striking, and it is stated that under the cultivation and moist conditions both of Malay and Sumatra, this increase in thickness and proportion of pulp takes place.

Column 4 gives the result of examination of nineteen types of West African fruits carried out by H. Jumelle. While they represent a great variety of fruits, the sample included many extreme types, and may not quite accurately portray results obtained on plantations.

In Column 5 estimates given by Van Pelt, Malet, and Janssens of the industry in French, British, and Belgian West Africa are combined. The figures probably, therefore, represent fairly accurately the average composition of fruits from uncultivated palms.

It will be realized that, in the absence of a systematic plantation industry, it is not possible to obtain accurate average figures for the composition of the fruits. The figures

given must, therefore, be frankly recognized as to some extent doubtful, and must be used with care when making estimates of returns from projected plantations. From these figures, however, and from current reports on the West African industry it is possible to accept the following percentages as fairly safe estimates of results to be expected from average fruits :—

Pulp oil, per cent. fruit	20
Kernel oil, per cent. fruit	7
Cake, per cent. fruit	8
Palm oil, per cent. pulp	55
Kernel oil, per cent. kernel	55
Kernel oil, per cent. whole seed ..	11

YIELDS PER TREE AND PER ACRE.

The references to yield which are found scattered through different publications are nearly all based on observations of individual trees, or are mere estimates based on the weight of fruit bunches and the number of bunches on observed trees. In the case of the West African industry the trees are irregular and scattered, and the methods of reaping the fruit and pressing the oil are wasteful and primitive, so that it does not appear to have been possible to obtain accurate records from a known area.

It is obvious that records from individual trees, uncultivated and perhaps isolated, cannot afford sound data for estimating the yields of trees in regular, cultivated plantations. Cultivation increases the average yield per tree, but, on the other hand, uncultivated trees, isolated from competition with others, very frequently do give yields higher than the average of plantation trees. In the present state of the oil palm industry, therefore, it is not possible to do more than roughly guess or estimate the probable yield per acre, using as a guide those figures which are available.

Estimates of the annual yield per tree vary from 50 to 150 lb. of fruit. Malet gives 150 lb. as a figure for good palms in West Africa, Van Pelt gives 50 as the usual yield, French figures for Dahomey trees give 59 lb., while Adam states that good Dahomey trees yield 85 lb. of fruit a year. These figures are for uncultivated palms, and it is clear that it would not be safe to assume an average of more than 60 lb. from trees growing under these conditions.

The only records from plantation palms are those obtained by A. A. L. Rutgers from a block of 17 acres in Sumatra.

Plate IV. Young oil palm, Anuradhapura Experiment Station